

Comprehensive Community Model for Physical Processes in the Nearshore Ocean

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LONG-TERM GOAL

Our goal is to develop a comprehensive, verified community model that predicts Nearshore hydrodynamics, sediment transport, and seabed morphology changes given offshore wave conditions and initial bathymetry.

OBJECTIVES

The basic scientific objective is to synthesize understanding of physical processes in the nearshore ocean by developing a model for

- waves and resulting radiation stresses and mass fluxes over evolving coastal bathymetry and currents
- wave-induced circulation
- sediment transport and morphological evolution

Additional objectives include developing techniques to assimilate observations into model predictions, and to test model components and the full community model with field observations.

APPROACH

Our approach is to develop a tightly-coupled system of individual model components, or modules. We are utilizing a framework where wave processes are distinguished from wave-averaged processes by means of a suitable time average. The resulting set of modules and their functions are:

- (1) wave module - calculation of second- and third-moment wave properties, including frequency-directional spectra, radiation stresses, and wave skewness and asymmetry
- (2) circulation module - calculation of wave-driven circulation and turbulence levels
- (3) seabed module - calculation of local sediment fluxes and seabed changes resulting from flux divergences, and characterization of bed geometry

A model backbone will allow interaction and feedback between the individual modules, as well as provide an interface to users. Candidate models to be used within each module are being investigated to provide a complete system with a set of tested components. However, the model backbone will be constructed as an open architecture with a documented set of required inputs and outputs for each component, allowing an end user to provide alternative formulations for each module.

Wave modules based on energy balances and on frequency domain Boussinesq or mild-slope equations are being investigated. Phase resolving formulations will allow detailed time series of waves to be simulated, and stochastic approaches will allow waves over large nearshore regions to be modeled. Breaking wave dissipation will be included to model waves propagating across the surf zone.

Circulation will be modeled with SHORECIRC and with the Princeton Ocean Model. SHORECIRC solves the short wave averaged equations including the 3-dimensional structure of mean and infragravity band currents using forcing and mass flux calculations provided by the wave module. A model for turbulence generated by wave breaking, the bottom boundary layer, and mean flows will be included in the SHORECIRC circulation module. The Princeton Ocean Model is a finite-difference approximation to the hydrostatic primitive equations with a free surface, and includes equations for continuity, momentum, temperature, and salinity. The Mellor-Yamada level 2.5 turbulence closure is used. Forcing by breaking waves and mass flux is parameterized.

The seabed module will model the local flux of sediment and the evolution of seafloor sedimentology and morphology. Field observations are being used to develop models for sediment flux driven by near-bottom velocities. Conservation of mass allows sediment flux calculations to be used to predict changes in large scale nearshore bathymetry. The effects of bedforms such as ripples and megaripples will be incorporated into the modules.

Model components, and eventually the full community model, will be tested by comparison with field observations. Waves, currents, seafloor morphology, and bathymetric evolution observed on the Outer Banks of North Carolina (Figure 1) during several few-month long field experiments are being reduced to common formats for model testing. Observations from other locations also will be available for

model testing. In addition, techniques to assimilate observations of Nearshore waves and circulation into model predictions are being investigated.

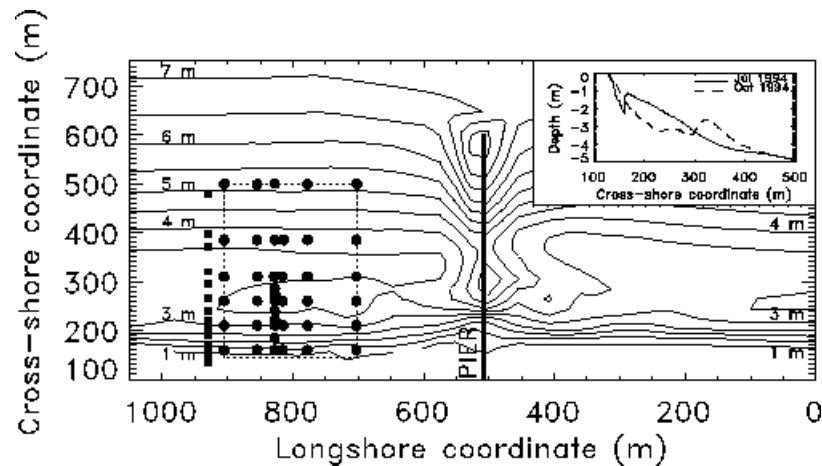


Figure 1. Planview showing locations of colocated pressure sensors, bidirectional current meters, and altimeters during Duck94 (squares) and SandyDuck (circles). Contours are depth below mean sea level on 12 Oct 1997 (SandyDuck). The cross-shore depth profiles in the inset panel show that the sandbar crest migrated 150 m offshore between Jul and Oct (Duck94). An objective of this project is to test the NOPP community model with observations of waves, currents, and bathymetric evolution acquired with the sensor arrays shown here.

WORK COMPLETED

An organizational meeting was held to establish first year activities and to select a steering committee. Working groups were formed in the areas of

- (1) surface wave dynamics
- (2) wave-induced circulation and turbulence
- (3) sediment transport and seabed morphology
- (4) verification and data assimilation

Groups (1)-(3) are pursuing the development and testing of individual modules with the goal of advancing the science in each, as well as defining how each module will interact most effectively with the other model components. Group (4) is investigating the utility of inverse methods for estimating nearshore circulation model parameters from field observations, and is assembling a WWW site for Duck94 field data that can be used by the NOPP partners to test individual modules.

IMPACT/APPLICATION

This is a new start (Aug 1999).

TRANSITIONS

The model system under development will provide a comprehensive predictive tool for Nearshore processes, and will have a wide range of uses in the scientific community, as well as in DoD and civil planning and operations.

RELATED PROJECTS

The investigators in the NOPP project have a range of individual projects with closely related science and modeling objectives. The NOPP model development effort benefits these other ongoing studies by providing increased collaboration and exchange of results and data among the partners. The NOPP project allows results from individual investigations to be synthesized into a community-wide model for nearshore processes.